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(71) Applicants
The Welsh National
School of Medicine
(Great Britain),
Heath Park, Cardiff,
Glamorgan
(72) Inventors
Ralph John Marshall,
Ronald Marks
(74) Agents
Wynne-Jones Laine and
James,
Morgan Arcade
Chambers, 33 St.Mary
Street, Cardiff, Glamorgan

(54) **Measuring surface roughness**

(57) A housing 1 on an adjustable support 2 incorporates a lighting source 4 for projecting a light beam at an angle onto a rough surface 3, e.g. skin. Reflections from the surface 3 are observed by a video camera 5 whose output is led to a control unit 6 incorporating a microprocessor for analysing the signals and displaying a trace of the surface texture on a screen 7. A roughness value is calculated by analysing the light density variation along a line portion of the surface and comparing this with a standard value. The reflections may instead be photographed and light transmitted through the negative along the line portion. A graphical trace of the light density may be made and the roughness value taken as the trace length or calculated from the mean peak to peak frequency or amplitude, the integral of the area to both sides of the mean or from a Fourrier analysis.

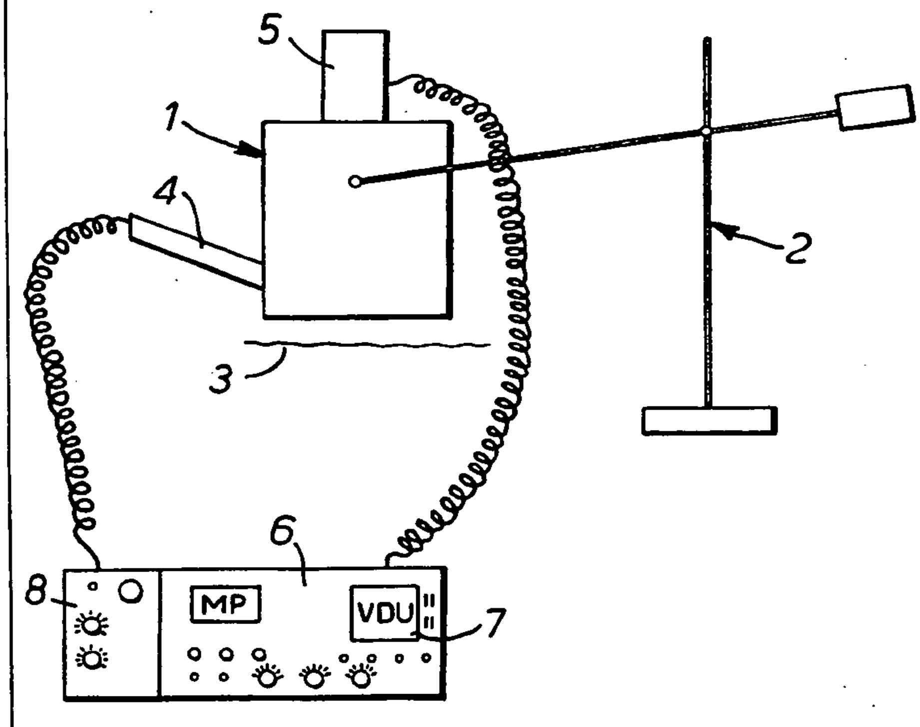

FIG. 1.

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.
This print takes account of replacement documents later filed to enable the application to comply with the formal requirements of the Patents Rules 1978.

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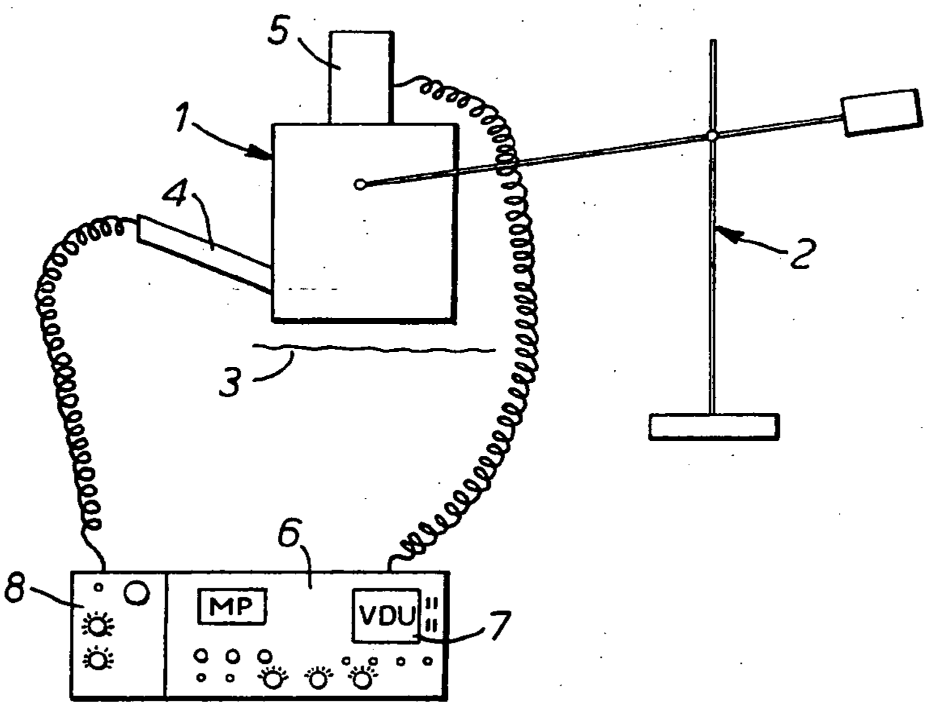

FIG. 1.

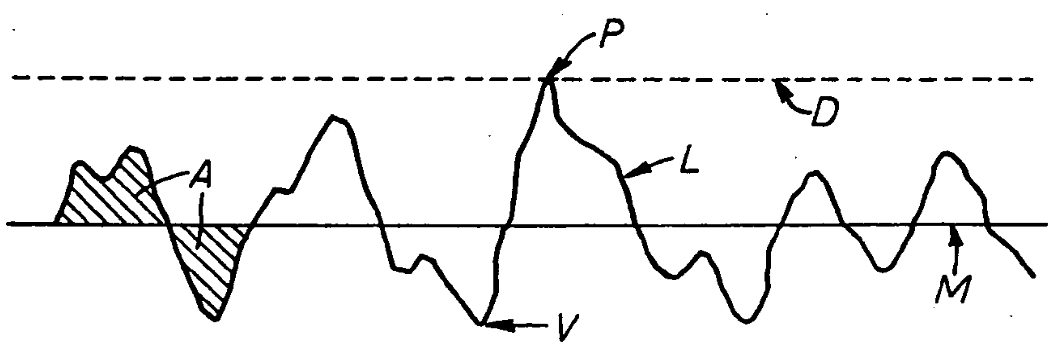

FIG. 2.

SPECIFICATION

Improvements relating to methods and apparatus for measuring surface roughness

This invention is concerned with means for measuring the roughness of surfaces, for example the surface of human skin. It is often necessary to be able to assign a value to skin roughness, such as when monitoring the efficiency of skin care cosmetic products. The extent to which such products are effective in smoothing the skin surface can be checked by analysing the degree of roughness of the skin before treatment and at intervals of time subsequent to treatment.

A conventional method of evaluating the roughness of skin is to produce a very highly resolved skin cast and then to pass a stylus over the cast and produce a trace of the extent of vertical deviation of the stylus as it moves over the cast. However, this method is not very accurate for various reasons. The application of the cast material to the skin creates some distortion in the skin texture, and it is a multistage process that allows only a two dimensional evaluation to be made because the stylus has a very fine point. Furthermore, the stylus can damage and distort the cast as it moves over it.

It is an object of this invention to provide means whereby surface roughness may be analysed with a reasonable degree of accuracy and without affecting the surface under consideration whilst the analysis is being carried out.

Accordingly, from one aspect, this invention provides a method of determination of a scale value for surface roughness comprising illuminating the surface from a predetermined direction, analysing the variations in the density of light reflected from along a line portion of the surface and calculating a roughness value from the analysis of light density variation for that line with reference to a standard value.

Such a method offers several advantages, firstly the measurement is carried out without any contact being made with the surface being analysed so that no distortions to that surface are created. Also the method can be performed very rapidly (as compared, for example, with a method where a skin cast has to be made and cured as a first step). The method also enables measurements to be made of desired portions of the surface at will.

In the preferred embodiment, a scan line from the output of a video camera directed at the surface is analysed for light density variation. Ideally the video camera output will be analysed by an electronic analysis unit. If desired the output from the video camera could be applied to produce a trace on an oscilloscope.

An alternative method is to take a photograph of the light reflected from the surface and light is then passed through the negative photographic image and the light density transmitted through the negative is scanned along a desired line portion for analysis of light density variation. This has the advantage that a permanent photographic record of the surface being analysed is provided but it is a slower method than that utilising a video camera.

It may be preferred that a graphical trace of the light density variation should be printed in the form of a permanent record. A roughness value can then be determined from a mathematical analysis of the curve of the graphical trace. For example, the roughness value may comprise the length of the curve over a predetermined length of the line portion being analysed. This length could be calculated by running a distance measuring wheel over the curve. Other possible measures of roughness value which could be calculated include those calculated on the basis of the mean peak-to-peak frequency or amplitude, the integral of the area to both sides of a mean value, or a Fourier analysis of amplitude frequency of a predetermined portion of the curve.

Clearly where the method is carried out using a video camera associated with an electronic analysis unit, the unit itself can carry out the required mathematical analysis electronically and produce an output value which is a measure of the surface roughness.

The invention also extends to apparatus for determining a scale value for surface roughness comprising a support for mounting the equipment adjacent a portion of a surface to be analysed, a light source for directing a beam of light at a predetermined angle onto the surface, a video camera for recording the light reflected from the surface and an analysis unit linked to the output of the camera which is designed to calculate a roughness value based on variations in the density of light reflected from along a line portion of the surface, with reference to a standard value.

The invention may be performed in various ways and a preferred embodiment thereof will now be described with reference to the accompanying drawing, in which:—

Figure 1 is a diagrammatic illustration of apparatus for measuring the roughness of a surface, and

Figure 2 is a graph illustrating a trace which may be achieved using the apparatus of Figure 1.

The measuring apparatus shown in Figure 1 comprises a housing 1 carried by an adjustable support structure 2 so that the lower end of the housing 1 can be positioned at a predetermined spacing from a surface whose roughness is to be analysed, for example a skin surface 3. A lighting source 4 projects a light beam at an angle down onto the surface 3 and a video camera 5 records the reflection from the surface 3. The output from the camera 5 is led to a control unit 6 which incorporates a microprocessor for analysing the signals and a video display screen 7. A control portion 8 is also provided for enabling the intensity of the light produced by the lighting source 4 to be varied.

The enlarged image of the skin, illuminated at a constant angle, is an analogue of the texture or nature of the skin surface, since raised portions of the skin will create shadows and the height of

each raised portion will determine the length and intensity of each shadow. The display produced on the screen 7 will be a picture of the skin and the operator can choose a desired area in the form of a line across the screen so that an adjacent pair of lines from the roster of the television image will be displayed as a single line trace on an oscilloscope such as in the form illustrated in Figure 2. This single line trace can be studied and will also be analysed by the microprocessor within the control box 6 which will be programmed to provide standard roughness parameters.

Referring now to the trace in Figure 2, various reference parameters may be calculated as follows. Firstly, the integral of the area (A) to both sides of a mean value (M) can be calculated and will obviously increase as the roughness of the skin increases. Another measurement is of the frequency or amplitude of the various peaks (P) above the mean line (M). The plot can be divided into equal increments and by calculating the valley (V) to peak (P) height of each increment a mean valley to peak height can be calculated over the whole plot. Another useful measure of roughness is the length of the trace line (L) over a predetermined length of plot. A surface roughness increases so tha number of peaks and valleys and the height and depth of these will increase, thus resulting in an increase in line length. Other possible measurements are of the mean depth below a datum line (D) and the maximum height of the peaks (P) over the portion of the trace being analysed. Another measure which has been found to be of value is of the harmonic coefficients of a Fourier series.

There are other methods of measuring roughness so as to assign a scale value to a particular sample. Of those discussed above, line length is a very convenient form of measurement since it can be calculated readily by running a distance measuring wheel over the curve of the form shown in Figure 2.

CLAIMS

1. A method of determination of a scale value for surface roughness comprising illuminating the surface from a predetermined direction, analysing the variations in the density of light reflected from along a line portion of the surface and calculating a roughness value from the analysis of light density variation for that line with reference to a standard value.

2. A method according to claim 1, wherein a scan line from the output of a video camera directed at the surface is analysed for light density variation.

3. A method according to claim 2, wherein the video camera output is analysed by an electronic analysis unit.

4. A method according to claim 2 or claim 3, wherein the output from the video camera is applied to produce a trace on an oscilloscope.

5. A method according to claim 1, wherein a photograph is taken of the light reflected from the surface and light is passed through the negative photographic image and the light density transmitted through the negative is scanned along a desired line portions for analysis of light density variation.

6. A method according to any one of claims 1 to 5, wherein a graphical trace of the light density variation is printed in the form of a permanent record.

7. A method according to claim 6, wherein the roughness value is determined from a mathematical analysis of the curve of the graphical trace.

8. A method according to claim 7, wherein the roughness value comprises the length of the curve over a predetermined length of the line portion being analysed.

9. A method according to claim 8, wherein the length is calculated by running a distance measuring wheel over the curve.

10. A method according to claim 7, wherein the roughness value is calculated on the basis of the mean peak-to-peak frequency or amplitude, the integral of the area to both sides of a mean value, or a Fourier analysis of amplitude frequency of a predetermined portion of the curve.

11. Apparatus for determining a scale value for surface roughness comprising a support for mounting the equipment adjacent a portion of a surface to be analysed, a light source for directing a beam of light at a predetermined angle onto the surface, a video camera for recording the light reflected from the surface and an analysis unit linked to the output of the camera which is designed to calculate a roughness value based on variations in the density of light reflected from along a line portion of the surface, with reference to a standard value.

12. A method or apparatus for determination of a scale value for surface roughness substantially as herein described with reference to the accompanying drawings.

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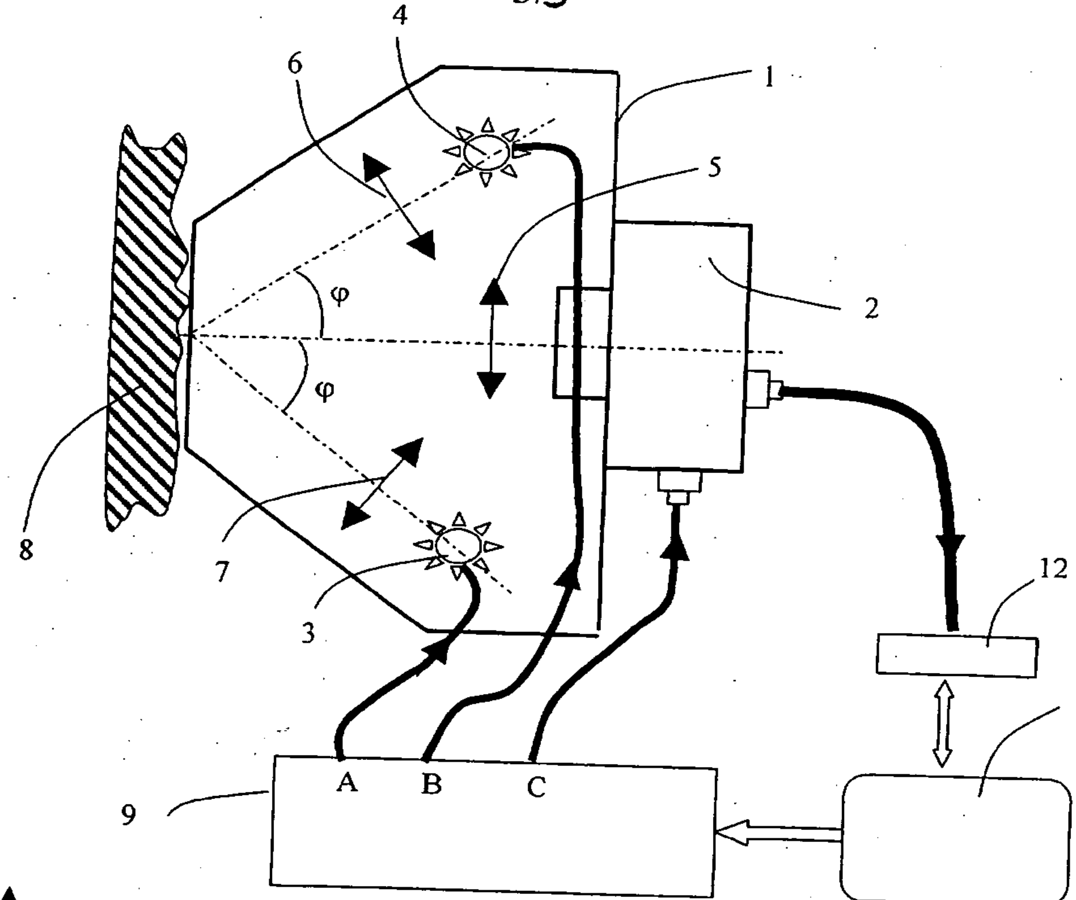

FIG.4

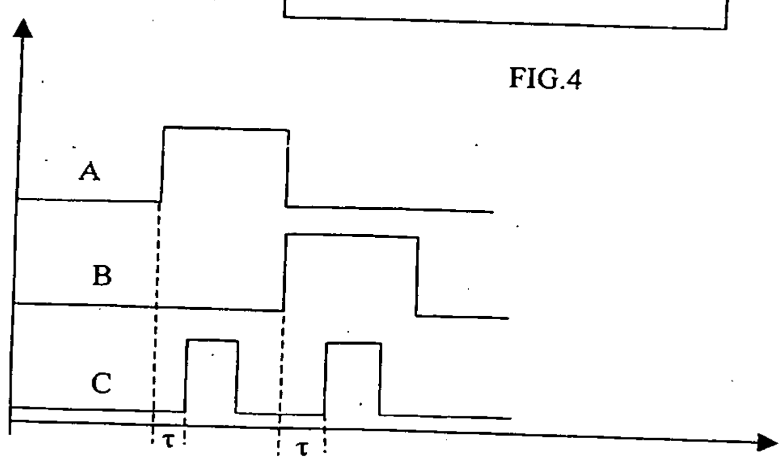

FIG.5